A Thermodynamic Investigation of the Early Afternoon Wet Microburst Pre-Storm Environment over Southern Alabama and the Western Florida Panhandle

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Introduction

Using Eglin Air Force Base (KVPS), Florida afternoon rawinsonde sounding data, this study investigated the thermodynamic characteristics of the summertime U.S. Gulf Coast wet microburst environment. Uniquely, these soundings sampled the troposphere during a period (1700-2100 UTC) of peak boundary layer mixing and thermodynamic instability prior to deep convection release.

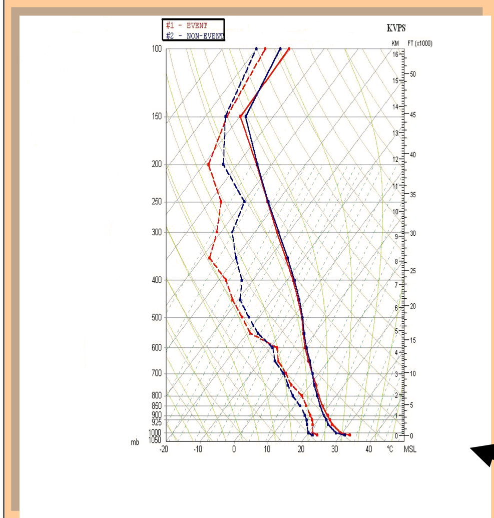

Fig. 1. Skew-T/Log-p composite of the non-event (red, #1) and event (blue, #2) mean soundings. Dewpoint temperature profiles are dashed. Figure were generated using ***Environmental Research Services, Rawinsonde Observation Program (RAOB)***, *ver. 5.4*. Copyright (1994-2003).

Methodology

•Using *early afternoon* KVPS sounding data, this research examined the early afternoon local pre-storm environment during the months of June, July and August (JJA) from 1998-2003.

•The thermodynamic characteristics of those soundings released in weak vertical wind shear (.003 s^{-1} of shear existing over 0-2.5 km) conditions.

•A wet microburst event day is defined as any day that a severe thunderstorm wind gust (>25.7 m s^{-1} or >50 kt) occurred within 125 km radius of KVPS from 1700-0000 UTC.

•Of a possible 270 JJA soundings from 1998-2003, 193 were retained for examination

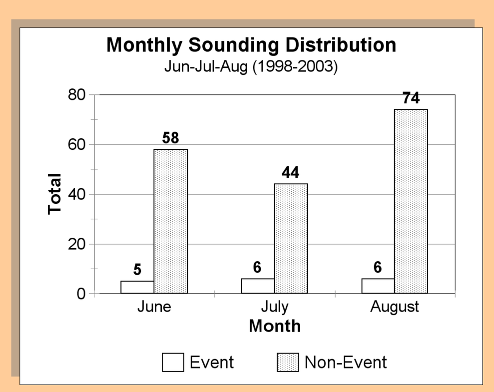

Fig. 2. Monthly distribution of soundings for event days (17, solid) and non-event days (176, hatched).

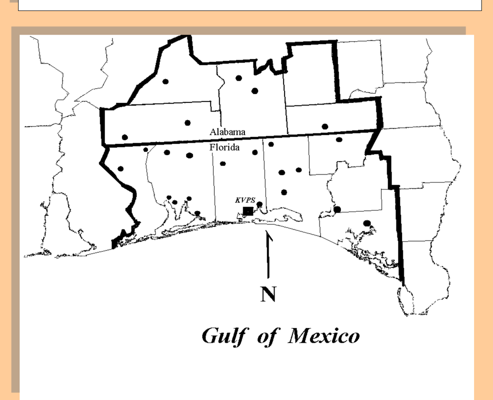

Fig. 3. Regional distribution of severe thunderstorm wind gusts in study domain for all 1998-2003 JJA days and location of KVPS sounding site (square). Note that some of the 17 event days were associated with more than one report.

Results

Seasonal Progression

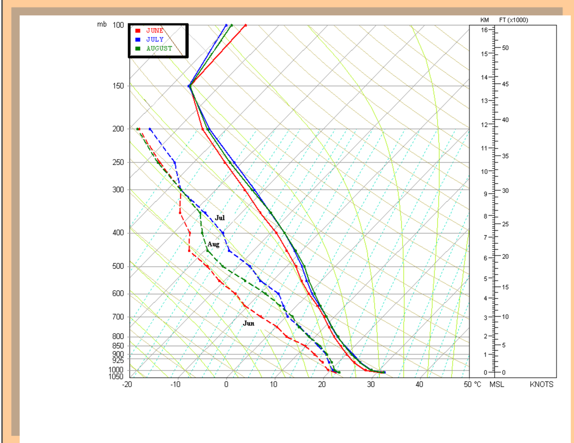

Fig. 4. Mean monthly Skew-T/Log-p sounding composite for June (red), July (blue), and August (green) based on all data for the period 1998-2003 (includes all event and non-event days). Temperatures are solid and dewpoint temperatures are dashed.

•Between June and July, a net 1.1 C of mean warming occurred throughout the depth of the profile. Between July and August, less than a tenth of a degree of net warming.

•Between June and August, dewpoint temperatures progressively moistened at each level, with the exception of notable drying (3.1 C) in the 650-300 mb layer from July to August (more later).

Event vs. Non-Event Mean Soundings

•The event sounding was found to be warmer and more moist below the melting level. Vice versa above.

•Both soundings possessed:
- sfc-1000 mb superadiabatic LR
- 1000-900 mb dry adiabatic LR
- Non-event sounding slightly more stable (~800-900 hPa)

•Event sounding more unstable:

SBCAPE $_{eve}$ = 3232 J kg^{-1}
(θ=304 K, w=17.5 g kg^{-1})

SBCAPE $_{non}$ =1853 J kg^{-1}
(θ=302 K, w=16 g kg^{-1})

•The 300 and 400 mb levels were drier on event days. This layer (~24-31 kft AGL) is where strong developing updrafts first grow above the -20 C level. Obviously, it is very important for developing updrafts to reach the 'dry layer' which is mainly composed of ice [potentially severe elevated high reflectivity cores (>55 dBz) are first detected in this layer.]

•Compared to the mean Non-Event sounding, the mean Event Day sounding possessed (higher\greater):

- Precipitable Water (1.72 vs 1.58 in.)
- Sfc-freezing level LR (7.6 vs. 7.2 C km^{-1})
- MLCAPE (2174 vs. 953 J kg^{-1})
- Sfc-900 mb mean MIXR (15.8 vs. 14.2 g kg^{-1})

Results

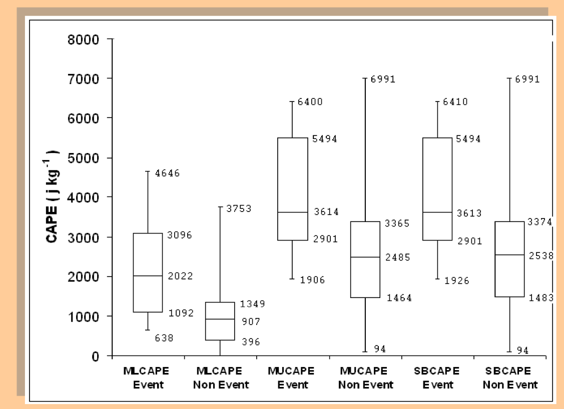

Fig. 5. - Box and whisker plots of ML-, SB- and MUCAPE (J kg-1) values for wet microburst event and non-event days.

Thermodynamic Instability

•MLCAPE event and non-event distributions show more separation, and with less variance, compared to the MUCAPE distributions.

•MLCAPE shows a distinct separation between the upper 50% of the event distribution and the lower 50% of the non-event distribution (>2021 J kg^{-1} for events and <908 J kg^{-1} for non-events). MLCAPE may be of greater operational utility as the 'mixed layer method' is more meteorologically consistent with the state of the early afternoon boundary layer.

•It appears wet microburst occurrence becomes relatively much higher when MLCAPE >3095 J kg^{-1}. It is worth emphasizing that 75% of the non-event MLCAPE distribution lies below 1350 J kg^{-1}.

•One should be reasonably confident that observed MLCAPE values <1349 J kg^{-1} are not likely to produce updrafts strong enough to reach well into the dry layer, thus producing relatively weaker downdrafts.

•Event vs. non-event sfc-900 mb mean *w* values are 15.8 vs. 14.2 g kg^{-1}, respectively. **The 1.6 g kg^{-1} difference is enough to provide ~900 J kg^{-1} of CAPE given a constant surface temperature of 304 K (or 32.8 C).

Lapse Rate and Boundary Layer Moisture

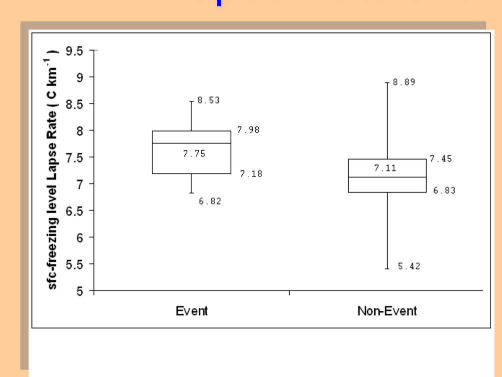

Fig. 6 – Same as in Fig. 5, but for SFC-freezing level lapse rate (C km^{-1}).

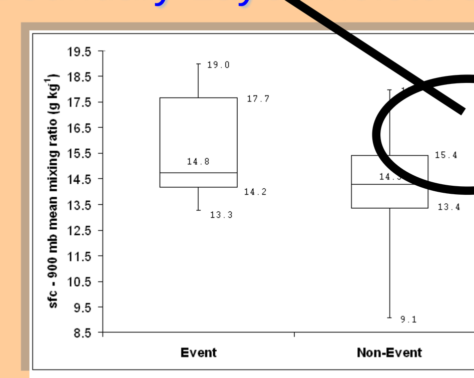

Fig. 7 – Same as in Fig. 5, but for SFC-900 hPa mixing ratio (g kg^{-1}).

•Srivastava (1987) used a model to determine that downbursts are 'practically impossible' with lapse rates <5 C km^{-1}, but become more likely when >6 C km^{-1}. It is interesting that both the event and non-event values in this study are much larger than 6 C km^{-1}.

•Sfc-freezing level lapse rates were 7.6 C km-1 vs. 7.2 C km^{-1} for event and non-event days, respectively.

Conclusions

•The chance of a wet microburst occurring was found to be relatively much higher when:

- **MLCAPE >3095 J kg^{-1}**
- **Sfc-900 mb mean mixing ratio >17.6 g kg^{-1}**
- **Sfc-freezing level lapse rate >7.98 C km^{-1}**

•The chance of a wet microburst occurring was found to be relatively much lower when:

- **MLCAPE <1350 J kg^{-1}**
- **Sfc-900 mb mean mixing ratio <13.5 g kg^{-1}**
- **Sfc-freezing level lapse rates <6.83 C km^{-1}**

•Wet microburst event day soundings are more moist than their non-event counterparts.

•Merely having relatively cold temperatures above the melting level cannot alone account for the production of wet microbursts.

•700-500 mb lapse rate provides little discriminatory forecast information.

Referenced Literature

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